DOE/GO-102001-1165
NREL/BK-710-29267
May 2001

8.2 Controlling Soil Gases

The entry into buildings of soil gases—including, but by no means limited to, radon—is an important area of concern. The few studies that have investigated soil gas entry report that 1–20% of the outdoor air entering buildings enters from below grade. Some gases, such as radon and hydrocarbons (from fuel or chemical spills), are health and safety risks to building occupants. Others, principally water vapor, may put the building at risk or cause secondary IAQ problems such as mold growth. Controlling soil gases is an important priority to ensure a safe working or living environment. Fortunately, the strategies for keeping soil gases out are relatively easy.

Opportunities

Soil gases are very easy to control in new buildings through proper design and construction practices. Specific measures for soil gas control should be included in all new buildings, but they are especially important in areas known to have high soil radon levels, on brownfield sites, and on land previously used for agriculture. In existing buildings, dealing with soil gas problems is more difficult and more expensive—but still doable. Before investing in a soil-gas remediation program in an existing building, however, test the area carefully to determine the type and extent of the contamination.

Technical Information

In order for radon or other soil gases from an underground source to end up in a building, there must be a way for the soil gases to enter (passageways) and a driving force to bring them in. The driving force is usually a combination of differences in air pressure (airflow through the below-grade material) and differences in contaminant concentrations. Passages include pores in the soil matrix, fissures and cracks in the underlying bedrock, porous fill around buildings, and cracks and holes in the building foundation walls and floor.

The most common driving force is negative pressure in the building. Exhaust fans, the stack effect, or air-handler returns may create negative pressure in the basement or crawl space that draws air from the soil into the building. Natural systems can also be the driving force. For example, a low-pressure weather system accompanied by a heavy rain may force the soil air mass to equalize with atmospheric air through a building. Rapidly rising water tables displace a large amount of soil air, generating positive pressure in the soil around a building. Air moves easily through gravel and rock that is fractured or has been dissolved by water, so pressure differentials can move large amounts of underground air and soil gases.

UNDERSTANDING SOIL GASES

The soil air contaminants we know the most about are radon, vapors from petroleum products, gases released by other volatile compounds, gases released by anaerobic or aerobic decomposition of carbon-containing materials, and water vapor.

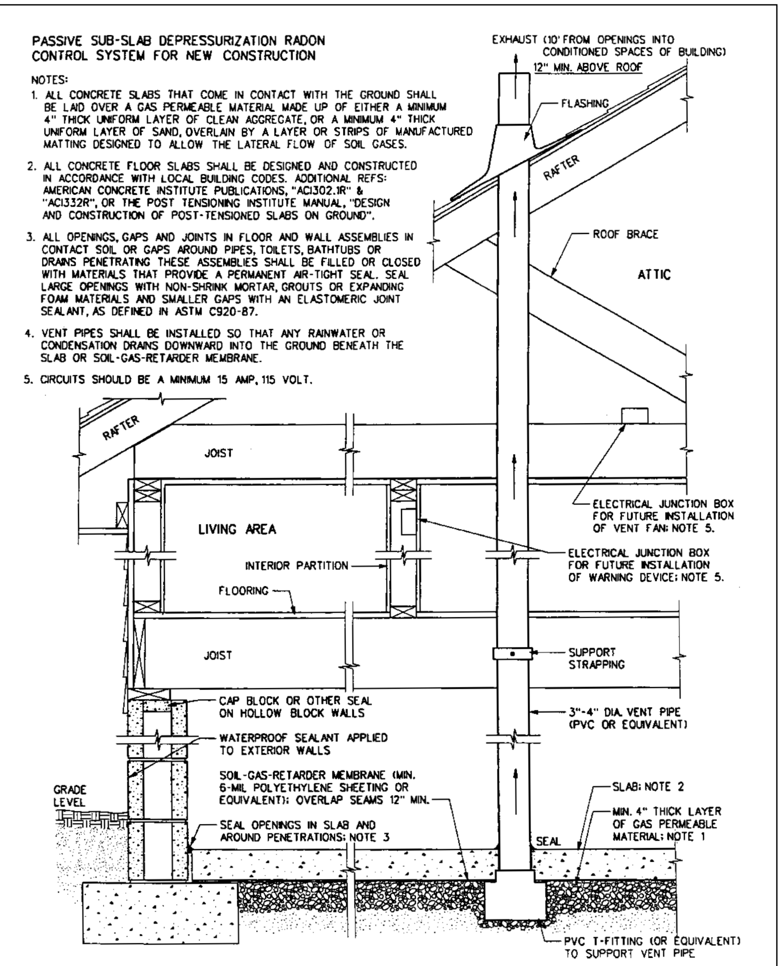
Radon is a radioactive gas released when radium, a trace element in many soils, undergoes nuclear decay. These decay products include radon and various other radioactive "daughter products" from the breakdown of radon. The only known health effect from exposure to radon and its short-lived decay products is an increased risk of lung cancer. Radon is the only carcinogen that is documented with human exposures at levels that may actually occur in buildings. It is classified by the EPA as a Group 1 (known human) carcinogen and is considered the second leading cause of lung cancer in the United States (after tobacco).

Gasoline and fuel oil are the most common sources of below-grade petroleum vapors. These hydrocarbons can get into the soil through spills, leaks, and intentional dumping. Gasoline fumes present an explosion hazard at levels of 14,000 ppm; fuel oil vapors entering a building are not generally explosive. Petroleum products contain a host of other compounds, including benzene, toluene, ethyl-benzene and xylenes (collectively referred to as BTEX). Although there are many other compounds released by petroleum products, these BTEX compounds are always present and pose substantial health risks; they can be detected very easily with portable, relatively inexpensive equipment.

Nonpetroleum VOCs disposed of underground or present in contaminated groundwater can be a big problem if they make their way into buildings. The best known example is the contamination at Love Canal in New York State. Common VOC soil gases include solvents, thinners, and de-icers—the constituents are as varied as the activities that produced them. A wide variety of short-term and long-term health effects could result from exposure to VOCs, depending on the contaminant(s) involved.

Buried materials that contain carbon are often decomposed by bacteria or fungi. Fungi most commonly digest organic matter in the presence of oxygen (aerobic decomposition), while bacteria generally operate in the absence of oxygen (anaerobic decomposition). Gases released by aerobic decomposition are primarily carbon dioxide, water vapor, and trace VOCs; the associated smell is often described as "moldy," "musty," or "earthy." Compounds released by anaerobic bacterial decomposition include methane, nitrogen, hydrogen, and sulfur compounds—and the associated smell can be very bad (often described as "old socks," "locker room," "rotten food," and "sewer gases"). Landfills contain a lot of buried organic matter that decomposes anaerobically, producing methane. Methane reaches explosive concentrations at 40,000 to 150,000 ppm, depending on the temperature and oxygen content. Such explosions have occurred at landfill sites. Buildings near landfills may end up with high methane levels—rarely at explosive concentrations but often at levels where the methane and associated gases can cause "nuisance odor" and health risks.

Water vapor is not itself a contaminant, but it creates an environment that can support populations of fungi, bacteria, mites, insects, or rodents. Potentially high levels of water vapor can enter a building from the ground. Whether this water vapor becomes a problem depends on the rate at which it is being added to and removed from the building by other means. Some studies have shown that strategies to keep soil gases out of buildings can significantly reduce indoor humidity levels.



This schematic illustrates the basic operation of a soil-gas control and mitigation system for a residence. Source: EPA 402-95012, May 1995

DEALING WITH SOIL GASES

A two-prong approach is recommended: prevent soil gas entry and provide dilution ventilation air as called for by codes or professional guidelines.

Preventing soil air entry is the primary control method. It solves soil gas problems that would be impractical to solve using ventilation alone. To prevent soil air entry:

- Provide a relatively airtight foundation;
- Avoid depressurization of the building through improperly balanced exhaust fans and air-handling equipment or through the stack effect (most pronounced in tall buildings);
- Provide a highly permeable layer of material beneath the building (e.g., crushed stone) that can be easily depressurized; and
- Install a passive stack that runs from the subslab layer through the heated part of the building to the outdoors.

The last two of these steps will create a low-air-pressure zone beneath the foundation that will intercept soil air and divert it through the passive stack. In the event that the passive stack is not powerful enough to keep problem gases out of the building, the stack can be powered with an in-line fan. Detailed correctly, a very small fan can treat a large footprint. In research conducted by the EPA, a single stack using a 90-watt fan has depressurized the drainage layer beneath a 100,000-square-foot (9,300 m^2) slab.

References

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